REMARKS

Claims 1-20 are all the claims presently pending in the application.

It is noted that the claim amendments made herein or later are not made to distinguish the invention over the prior art or narrow the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein or later should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

Applicants gratefully acknowledge the Examiner's indication that claims 14 and 19 would be allowable if rewritten in independent form including all the limitations of the base claim and any intervening claims. However, Applicants respectfully submit that all the claims presently pending are allowable.

Regarding the prior art rejections, claim 18 stands rejected under under 35 U.S.C. §102(b) as being anticipated by Armasow et al. (U.S. Patent No. 4,144,724). Claims 1, 3, 5, 7-9, 15 and 20 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Petrzelka et al. (U.S. Patent No. 4,371,357) in view of Kosuda et al. (U.S. Patent No. 4,445,875). Claims 2, 4, 6, 10-13 and 16-17 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Petrzelka et al. in view of Kosuda et al. and further in view of Olschewski et al. (U.S. Patent No. 4,436,516)

These rejections are respectfully traversed in the following discussion.

I. THE CLAIMED INVENTION

An exemplary aspect of the invention, as recited in claim 1, is directed to a cross shaft including a trunnion, a roller bearing externally provided at the trunnion, and a recess formed at a distal end face of the trunnion. A bottom region of the recess includes a spherical shape and a size of an opening region of the recess except the bottom region gradually increases toward an opening end of the recess.

A further aspect of the invention, as recited in claim 10, is directed to a cross shaft including a trunnion, a roller bearing externally provided on the trunnion including rollers arranged in a plurality of rows in parallel in an axial direction of the trunnion, a plurality of bearing rolling faces corresponding to the plurality of rows of rollers provided on an outer peripheral face of the trunnion reduced in diameter from a root of the trunnion toward a distal end of the trunnion, and a recess formed at a distal end face of the trunnion. The recess includes a bottom region including a spherical shape and an opening region including a tapered shape opening toward an opening end edge of the recess.

Another aspect of the invention, as recited in claim 18, is directed to a cross shaft including a trunnion, a roller bearing externally provided on the trunnion including rollers arranged in a plurality of rows in parallel in an axial direction of the trunnion, and a plurality of bearing rolling faces corresponding to the plurality of rows of rollers provided on an outer peripheral face of the trunnion. The plurality of bearing rolling faces are reduced in diameter from a root of the trunnion toward a distal end of the trunnion, and a radial clearance between the rollers and the rolling faces is increased for the plurality of rows from the root of the

trunnion toward the distal end of the trunnion. The diameters of the rollers comprising the roller bearing are the same.

In conventional trunnion structures, there has been a tendency for the rollers to break down when the contact face pressure of the rollers at the distal end of the trunnion is increased at a time of torque transmission under high load. To avoid such a break down, it is known to arrange the rollers in a plurality of rows in an axial direction along the trunnion, where the diameters of the rollers in respective rows are made successively larger toward the root of the trunnion in order to substantially equalize the contact face pressure at the time of torque transmission. (See Application at page 1, lines 13-25)

However, the higher the load during torque transmission, the larger the differences must be made between the diameters of rollers in the respective rows. As such, since the radial clearances of the rollers with respect to the trunnion must be made larger, the rollers become liable to skew. (See Application at page 2, lines 1-8)

It has also been proposed to provide a recess substantially in the shape of a frustum of a cone at the distal end of the trunnion to reduce the bending rigidity of the trunnion. In this manner, the trunnion can be flexed at the time of torque transmission, thereby reducing deflection of bending stress to the root of the trunnion. (See Application at page 2, lines 10-16) However, there are concerns that when a large recess is formed, rigidity of the trunnion with respect to the applied load may be insufficient. (See Application at page 2, lines 18-22)

An exempary aspect of the claimed invention, on the other hand, provides a trunnion having and a recess formed at a distal end face of the trunnion, wherein a bottom region of the recess includes a spherical shape and a size of an opening region of the recess except the

bottom region gradually increases toward an opening end of the recess. These features, amongst others, enable the trunnion to be flexed in its entirety from the root of the trunnion. When flexed in such a manner, the rollers are evenly brought into contact with their respective rolling faces and, as such, the concentration of the contact face pressure to the edges of the rollers is restrained. In this manner, the exfoliation life and bending strength of the rolling faces of the trunnion can be enhanced. (See Application at page 10, lines 3-14)

Another exemplary aspect of the claimed invention provides a trunnion having a plurality of bearing rolling faces reduced in diameter from a root of the trunnion toward a distal end of the trunnion, and a radial clearance between the rollers and the rolling faces increased for each of the plurality of rows from the root of the trunnion toward the distal end of the trunnion, wherein the diameters of the rollers comprising the roller bearing are the same. By forming the rolling faces in this manner, it is possible to equally distribute the contact face pressure exerted on the rollers during torque transmission, while preventing the rollers from skewing. (See Application at page 7, lines 13-17)

II. THE PRIOR ART REJECTIONS

A. The Armasow et al. Reference

The Examiner alleges that the invention of claim 18 is anticipated by Armasow et al. However, Applicants respectfully submit that the reference does not teach or suggest each and every element of claim 18.

However, Armasow et al. does not disclose or suggest "*a plurality of bearing rolling faces corresponding to the plurality of rows of rollers provided on an outer peripheral face of*

the trunnion, the plurality of bearing rolling faces being reduced in diameter from a root of the trunnion toward a distal end of the trunnion, wherein a radial clearance between the rollers and the rolling faces is increased for each of the plurality of rows from the root of the trunnion toward the distal end of the trunnion and diameters of the rollers comprising the roller bearing are the same," as recited in claim 18. (Emphasis added)

Instead, Armasow et al. discloses "that crosspin 44 has two progressively narrowed steps in its radial outer region. This can facilitate the introduction of the crosspin 44 into joint fork 40. The cylindrical roller bearings 45,46,46a all have the same raceway diameter, as in Fig. 3. The radially outer bearings 46 and 46a have respective inner races 47,47a." As is clearly shown in Figure 4 of Armasow et al., the inner races 47,47a are provided on the steps in the radial outer region of the crosspin 44 such that the radial clearances between the roller bearings 46,46a and their respective inner races 47,47a is the same as the radial clearance between roller bearings 45 and the crosspin 44. (See Armasow et al. at Figure 4 and column 6, lines 3-15)

The Examiner alleges that Figure 4 of Armasow et al. discloses "*a plurality of bearing rolling faces corresponding to the plurality of rows of rollers provided on an outer peripheral face of the trunnion, the plurality of bearing rolling faces being reduced in diameter from a root of the trunnion toward a distal end of the trunnion,*" as recited in claim 18. However, Figure 4 of Armasow et al. clearly shows that the crosspin 44 has only one roller bearing face provided on its outer peripheral face that corresponds to rollers 45. As noted above, Armasow et al. teaches that the radially outer bearings 46,46a have respective inner races 47,47a provided between the bearings 46,46a and the crosspin 44. Therefore,

Armasow et al. does not teach or suggest that the outer bearings 46,46a have corresponding bearing rolling faces on the crosspin 44.

In fact, Armasow et al. particularly indicates that the progressive steps of the crosspin 44 in Figure 4 do not include roller bearing faces by disclosing that "[t]he universal joint embodiment of FIG. 5 is a particularly favorable one, as far as construction costs are concerned." In particular, Armasow et al. differentiates the embodiments by noting that "[t]he cylindrical roller bearings 55,56 [in FIG. 5] bear directly on the crosspin, without an inner race." (See Armasow et al. at Figure 5 and column 6, lines 25-35) (Emphasis added)

Indeed, Armasow et al. actually teaches away from the crosspin 44 of Figure 4 having a plurality of bearing rolling faces provided on an outer peripheral face of the progressively stepped section of the crosspin 44 corresponding to the bearings 46,46a. In fact, Armasow et al. teaches that "if all cylindrical roller bearings are made with the same raceway diameter, there is an advantage of increased load capacity. However, in this mentioned embodiment, "it will always be necessary to support the cylindrical bearings which are arranged outside over an inner ring on the tapered region of the crosspin." Indeed, Armasow et al. further teaches that such an inner ring has the advantage of being "a replaceable wearing part so that the entire crosspiece is protected against wear." (See Armasow et al. at column 3, lines 22-36) (Emphasis added)

Clearly, the crosspin 44 of Figure 4 of Armasow et al. does not teach or suggest a plurality of bearing rolling faces provided on the outer peripheral face of the crosspin 44, and certainly does not teach or suggest a plurality of bearing rolling faces being reduced in diameter from a root of the crosspin 44 toward a distal end of the crosspin 44.

The Examiner further alleges that Armasow et al. teaches that "*a radial clearance between the rollers and the rolling faces is increased for each of the plurality of rows from the root of the trunnion toward the distal end of the trunnion and diameters of the rollers comprising the roller bearing are the same*," as recited in claim 18.

However, Armasow et al. makes no reference or suggestion to a radial clearance between the bearings 45,46,46a and their respective bearing rolling faces on the crosspin 44 and the inner races 47,47a. Armasow et al. certainly does not teach or suggest such a radial clearance being increased for each row of bearings 45,46,46a toward the distal end of the crosspin 44.

Similarly to the discussion above, Armasow et al. also teaches away from the radial clearance between the bearings 45,46,46a and their respective bearing rolling faces on the crosspin 44 and the inner races 47,47a being increased for each rows bearings from the root of the crosspin 44 toward the distal end of the crosspin 44 when the diameters of the bearings 45,46,46a are the same. As noted, Armasow et al. teaches that when all the cylindrical roller bearings are made with the same raceway diameter, "it will always be necessary to support the cylindrical bearings which are arranged outside over an inner ring on the tapered region of the crosspin." (See Armasow et al. at column 3, lines 22-36) (Emphasis added)

Clearly, Armasow et al. does not teach or suggest that "*a radial clearance between the rollers and the rolling faces is increased for each of the plurality of rows from the root of the trunnion toward the distal end of the trunnion and diameters of the rollers comprising the roller bearing are the same*," as recited in claim 18.

The invention of claim 18, on the other hand, provides a trunnion having a plurality of bearing rolling faces reduced in diameter from a root of the trunnion toward a distal end of the trunnion, and a radial clearance between the rollers and the rolling faces increased for each of the plurality of rows from the root of the trunnion toward the distal end of the trunnion, wherein the diameters of the rollers comprising the roller bearing are the same.

As noted above, by forming the rolling faces in this manner, it is possible to equally distribute the contact face pressure exerted on the rollers during torque transmission, while preventing the rollers from skewing. (See Application at page 7, lines 13-17) Clearly, Armasow et al. does not teach or suggest such features. Indeed, Armasow et al. does not even recognize the desirability or benefits of providing such features.

In light of the above, Applicant submits that Armasow et al. does not teach or suggest each and every element of claim 18. Therefore, the Examiner is respectfully requested to withdraw this rejection.

B. The Petrzelka et al. and Kosuda et al. References

The Examiner alleges that Petrzelka et al. would have been combined with Kosuda et al. to form the inventions of claims 1, 3, 5, 7-9, 15 and 20. However, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

Petrzelka et al. discloses a universal joint formed with trunnions extending into the bores of yokes with bearing bushes being interposed between the trunnions and yokes. (See Petrzelka et al. at Abstract)

Kosuda et al. discloses a universal joint including a journal cross shaft having cross arms and yokes and spline shafts. (See Kosuda et al. at Abstract)

Applicant respectfully submits that these references would not have been combined as alleged by the Examiner. Indeed, no person of ordinary skill in the art would have considered combining these disparate references, absent impermissible hindsight.

In fact, Applicant submits that the Examiner can point to no motivation or suggestion in the references to urge the combination as alleged by the Examiner. Indeed, contrary to the Examiner's allegations, neither of these references teaches or suggests their combination.

Therefore, Applicant respectfully submits that one of ordinary skill in the art would not have been so motivated to combine the references as alleged by the Examiner. Therefore, the Examiner has failed to make a prima facie case of obviousness.

The Examiner concedes that Petrzelka et al. does not teach or suggest "*a recess formed at a distal end face of the trunnion, wherein a bottom region of the recess comprises a spherical shape*," as recited in claims 1, 3, 5, 7-9, 15 and 20. Rather, the Examiner attempts to rely Kosuda et al. to make up for the deficiencies of Petrzelka et al.

However, this feature is not taught or suggested Kosuda et al. In fact, nowhere do the cited figures or passages teach or suggest that the trunnion is provided with a recess formed at a distal end face of the trunnion, wherein a bottom region of the recess includes a spherical shape.

Instead, Kosuda et al. discloses a journal cross 2 having four journal cross arms 4 including a grease nipple 12 through which grease is provided to oil reservoirs 14 formed in the journal cross arms 4 through oil supply apertures 12. (See Kosuda et al. at Figure 1 and

column 2, lines 25-42) Kosuda et al. teaches that "within the oil reservoir 14 is provided an oil controller 10 in the form of a cylindrical cup having a seat made of a porous plastic material." Kosuda et al. further discloses that "the oil controller 10 snugly fitted in the oil reservoir 14 has an inner end, that is preferably hemispherical." (See Kosuda et al. at Figure 1 and column 2, lines 43-50) (Emphasis added)

Thus, Kosuda et al. only discloses that the inner end of the oil controller 10 may be hemispherical. The Examiner presumably believes that the "hemispherical" shape of the oil controller 10 would teach the "spherical" shape of the bottom region of the recess in the present invention. However, as indicated above, the oil controller 10 is a porous plastic cup snugly fitted within the oil reservoir 14. Thus, the shape of the inner end of the oil controller 10 is not the shape of the recess formed in the outer end of the journal cross arm 4 by the oil reservoir 14. In fact, Kosuda et al. makes no mention of the shape of the oil reservoir 14 formed in the journal cross arm 4. The only suggestion in Kosuda et al. of the shape of the oil reservoir 14 is provided by Figure 1, which merely shows the oil reservoir 14 having a cylindrical shape with a tapered edge leading into the oil supply aperture 12. Clearly, Kosuda et al. does not teach or suggest that the shape of any portion of the oil reservoir 14 may be hemispherical or spherical.

The inventions of claims 1, 3, 5, 7-9, 15 and 20, on the other hand, provide a trunnion having a recess formed at a distal end face of the trunnion, wherein a bottom region of the recess includes a spherical shape. As noted above, this feature, amongst others, enables the trunnion to be flexed in its entirety from the root of the trunnion. When flexed in such a manner, the rollers are evenly brought into contact with their respective rolling faces and, as

such, the concentration of the contact face pressure to the edges of the rollers is restrained. In this manner, the exfoliation life and bending strength of the rolling faces of the trunnion can be enhanced. (See Application at page 10, lines 3-14)

The Examiner appears to simply rely on the shape of the oil controller 10 disclosed in Kosuda et al. However, there is no teaching or suggestion in Kosuda et al. that the hemispherical shape of the oil controller 10 may affect the flexure of the crosspin 44 in any manner. Rather, the only purposes taught by Kosuda et al. for the oil controller 10 are to control the flow of grease within a universal joint in order to reduce losses of grease and ensure complete lubrication of the joint, and to filter out foreign substances from the grease in order to reduce abrasion. However, there is no teaching or suggestion in Kosuda et al. that the hemispherical shape of the inner end of the oil controller 10 has any specific purpose.

Neither Petrzelka et al., nor Kosuda et al., nor any combination thereof, teaches or suggests "*a recess formed at a distal end face of the trunnion, wherein a bottom region of the recess comprises a spherical shape*," as recited in claims 1, 3, 5, 7-9, 15 and 20. Indeed, neither reference even recognizes the desirability or benefits of providing such a feature. Clearly, Kosuda et al. does not make up for the deficiencies of Petrzelka et al..

In light of the above, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of claims 1, 3, 5, 7-9, 15 and 20. Therefore, the Examiner is respectfully requested to withdraw this rejection.

C. The Olschewski et al. Reference

The Examiner alleges that Petrzelka et al. and Kosuda et al. would have been combined with Olschewski et al. to form the inventions of claims 2, 4, 6, 10-13 and 16-17. However, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

Olschewski et al. discloses a support means for trunnions including a bearing bushing having a sleeve section adapted to axially support the trunnion and a plurality of cylindrical rollers arranged in at least two side by side rows. (Olschewski et al. at Abstract)

Applicant respectfully submits that these references would not have been combined as alleged by the Examiner. Indeed, no person of ordinary skill in the art would have considered combining these disparate references, absent impermissible hindsight.

In fact, Applicant submits that the Examiner can point to no motivation or suggestion in the references to urge the combination as alleged by the Examiner. Indeed, contrary to the Examiner's allegations, neither of these references teaches or suggests their combination.

Therefore, Applicant respectfully submits that one of ordinary skill in the art would not have been so motivated to combine the references as alleged by the Examiner. Therefore, the Examiner has failed to make a prima facie case of obviousness.

The Examiner concedes that combination of Petrzelka et al. and Kosuda et al. does not teach or suggest that the trunnion is provided on an outer peripheral face thereof with a plurality of bearing rolling faces which are reduced in diameter from a root thereof toward a

distal end thereof. Rather, the Examiner attempts to rely on Olschewski et al. to make up for the deficiencies of Petrzelka et al. and Kosuda et al.

However, this feature is not taught or suggested Olschewski et al. In fact, nowhere do the cited figures or passages teach or suggest that the trunnion is provided on an outer peripheral face thereof with a plurality of bearing rolling faces which are reduced in diameter from a root thereof toward a distal end thereof.

Rather, Olschewski et al. discloses that "the inner race 25 of the row of cylindrical rollers 10 nearest the bottom section 9 of the bearing bushing 7 is of conical configuration and is slightly tapered radially outwardly toward the bottom section 9." (See Olschewski et al. at column 6, lines 23-27) However, "[t]he inner races 15 and 25 are located adjacent one another on the trunnion 6 without offset and are the same diameter." (See Olschewski et al. at column 6, lines 27-29) (Emphasis added) In contrast, in the inventions of claims 2, 4, 6, 10-13 and 16-17, the bearing rolling faces on the trunnion are reduced in diameter toward the distal end of the trunnion.

Olschewski et al. actually specifically teaches away from the claimed invention stating that when "the trunnion is tapered in steps towards its end in order to form inner races ... it has been found that the end of the trunnion experiences high bending stresses by reason of the fact that it is of relatively small diameter and also due to the high notch stress produced at the step or juncture between the inner races of the trunnion." (See Olschewski et al. at column 1, lines 25-34) As such, according to Olschewski et al., "[t]hese combined stresses produce material fatigue and failure of the trunnion." (See Olschewski et al. at column 1, lines 34-35)

Olschewski et al. goes on to teach that "[f]urthermore, a trunnion with stepped or offset inner races is rather difficult to and uneconomical to manufacture." (Olschewski et al. at column 1, lines 36-38) Clearly, Olschewski et al. teaches away from the inventions of claims 2, 4, 6, 10-13 and 16-17, in which the bearing rolling faces on the trunnion are reduced in diameter.

Clearly, neither Petrzelka et al., nor Kosuda et al., nor Olschewski et al., nor any combination thereof, teaches or suggests that "*the trunnion is provided on an outer peripheral face thereof with a plurality of bearing rolling faces which are reduced in diameter from a root thereof toward a distal end thereof*," as recited in claims 2, 4 and 6. (Emphasis added) Claims 10-13 and 16-17 contain similar language.

Further, Olschewski et al. fails to make up for the deficiencies of Petrzelka et al. and Kosuda et al. described above, directed toward providing a recess at a distal end face of the trunnion including a bottom region of the recess having a spherical shape, as in claims 2, 4, 6, 10-13 and 16-17, so that the trunnion can be flexed in its entirety from the root.

Thus, even assuming arguendo that Olschewski et al. may disclose a plurality of bearing faces which are reduced in diameter, as asserted by the Examiner, there is no teaching or suggestion in Olschewski et al. of a recess at a distal end face of the trunnion including a bottom region of the recess having a spherical shape, so that the trunnion can be flexed in its entirety from the root, as recited in claims 2, 4, 6, 10-13 and 16-17. Indeed, the cited reference does not even recognize the desirability or benefit of providing such a feature. Therefore, Olschewski et al. clearly does not make up for the deficiencies of Petrzelka et al. and Kosuda et al.

In light of the above, Applicant submits that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of claims 2, 4, 6, 10-13 and 16-17. Therefore, the Examiner is respectfully requested to withdraw this rejection.

IV. FORMAL MATTERS & CONCLUSION

The Examiner has objected to the drawings. In particular, the Examiner has objected to Figures 2 and 6 for not showing the thrust bearing 7. However, a thrust bearing is not presently claimed. Applicants respectfully note that 37 CFR 1.83(a) only requires that:

> *The drawing in a nonprovisional application must show every feature of the invention specified in the claims.*

(Emphasis added)

Notwithstanding, Applicants re-submit that this objection is improper because the thrust bearing 7 is clearly shown in Figure 1 and is not required be shown in other figures. The Examiner is respectfully requested to withdraw this objection.

The Examiner has further objected to the specification and has requested a substitute specification excluding the claims. Accordingly, Applicants submit herewith a "marked-up version" of the substitute specification showing changes and a "clean version" of the substitute specification. No new matter has been added.

In particular, the sentence on page 2, lines 21-22 objected to by the Examiner has been corrected to conform to proper English (See page 2, line 19 in the attached "marked-up version"), and a brief description of Figure 8 has been included in the Brief Description of the Drawings section (See page 5, lines 7-8 in the attached "marked-up version").

In view of the foregoing, Applicant submits that claims 1-20, all the claims presently pending in the application, are patentably distinct over the prior art of record and are allowable, and that the application is in condition for allowance. Such action would be appreciated.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned attorney at the local telephone number listed below to discuss any other changes deemed necessary for allowance in a telephonic or personal interview.

To the extent necessary, Applicant petitions for an extension of time under 37 CFR §1.136. The Commissioner is authorized to charge any deficiency in fees, including extension of time fees, or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 3/31/06

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